

WHAT IS CLAIMED IS:

1. An audio signal processing and reproducing method,  
comprising the steps of:

5 converting an analog audio signal of a channel into a  
digital audio signal composed of a plurality of pieces of  
audio data;

10 adding a plurality of pieces of sound quality control  
information, which each denote information for adjusting a  
sound quality of a music indicated by the analog audio signal,  
to the digital audio signal;

recording a set of the digital audio signal and the pieces  
of sound quality control information;

reading out the set of the digital audio signal and the  
pieces of sound quality control information;

15 selecting a piece of particular sound quality control  
information from the pieces of sound quality control  
information;

20 adjusting levels of the pieces of audio data of the digital  
audio signal according to the particular sound quality control  
information to produce a sound quality adjusted digital audio  
signal composed of a plurality of pieces of sound quality  
adjusted audio data having adjusted levels; and

outputting the sound quality adjusted digital audio signal.

25 2. An audio signal processing and reproducing method according

to claim 1 in which each piece of sound quality control information indicates the adjustment of the music in dependence on a category of the music such as classic, jazz, rock or background music, a playing condition of the music, a recording condition for the digital audio signal or circumstances of a reproducing condition of the digital audio signal.

3. An audio signal processing and reproducing method according to claim 1 in which the step of converting an analog audio signal of a channel into a digital audio signal includes a step of converting an analog audio signal into a digital audio signal for each of a plurality of channels, and each piece of sound quality control information includes graphic equalizer information indicating the change of the original levels of the pieces of audio data of the digital audio signal for each frequency band, level balance information indicating the change of the original levels of the pieces of audio data of the digital audio signal for each channel or reverberation adding information indicating the addition of reverberation to the music.

4. An audio signal processing and reproducing method according to claim 1, further comprising the steps of:

converting the sound quality adjusted digital audio signal into a sound quality adjusted analog audio signal to produce a sound quality adjusted music from the sound quality adjusted analog audio signal; and

5        outputting the sound quality adjusted music.

5. An audio signal processing and reproducing method according to claim 1 in which the step of adding a plurality of pieces of sound quality control information comprises the steps of:

10        limiting a frequency band of the digital audio signal to produce a series of band limited audio data of a band limited digital audio signal from the digital audio signal;

removing pieces of band limited audio data from the series of band limited audio data at prescribed intervals to produce  
15        a series of sampling frequency reduced data  $\{X_{ci}\}$  ( $i$  is a positive integral number) of a sampling frequency reduced signal from the series of band limited audio data;

thinning out pieces of data of the level-shifted digital audio signal at prescribed intervals to produce a series of  
20        thinned-out audio data  $\{X_{bi}, X_{ai}\}$  of a thinned-out audio signal in which the number of thinned-out audio data is double the number of sampling frequency reduced data;

calculating a difference  $\Delta li = X_{bi} - X_{ci}$  between the thinned-out audio data  $X_{bi}$  and the sampling frequency reduced data  $X_{ci}$   
25        to produce a series of first differential audio data  $\{\Delta li\}$ ;

calculating a difference  $\Delta 2i = X_{ai} - X_{ci}$  between the thinned-out audio data  $X_{ai}$  and the sampling frequency reduced data  $X_{ci}$  to produce a series of second differential audio data  $\{\Delta 2i\}$ ;

packing the series of sampling frequency reduced data  
5  $\{X_{ci}\}$ , the series of first differential audio data  $\{\Delta 1i\}$  and the series of second differential audio data  $\{\Delta 2i\}$  to produce a series of user data  $\{X_{ci}, \Delta 1i, \Delta 2i\}$ ; and

packing the series of user data and the pieces of sound quality control information to produce packed data, and  
10 the step of recording a set of the digital audio signal comprising the steps of:

recording the packed data in a digital versatile disk.

6. An audio signal processing and reproducing method according  
15 to claim 5 in which the step of reading out the set of the digital audio signal comprises the steps of:

reading out the packed data from the digital versatile disk;

reproducing the pieces of sound quality control information  
20 from the packed data;

reproducing the series of thinned-out audio data  $\{X_{bi}, X_{ai}\}$  from the packed data by adding each piece of sampling frequency reduced data  $X_{ci}$  to a corresponding piece of first differential audio data  $\Delta 1i$  and adding each piece of sampling  
25 frequency reduced data  $X_{ci}$  to a corresponding piece of second

differential audio data  $\Delta 2i$ ; and

interpolating pieces of data into the series of thinned-out audio data  $\{X_{bi}, X_{ai}\}$  to reproduce the pieces of audio data of the digital audio signal.

5

7. An audio signal processing apparatus, comprising:

analog-digital converting means for converting an analog audio signal of a channel into a digital audio signal composed of a plurality of pieces of audio data; and

10 audio signal coding means for adding a plurality of pieces of sound quality control information, which each denote information for adjusting a sound quality of a music indicated by the analog audio signal, to the digital audio signal and coding the digital audio signal and the pieces of sound  
15 quality control information to produce packed data, the packed data being transmitted or recorded.

8. An audio signal processing apparatus according to claim 7 in which the audio signal coding means comprises:

20 frequency band limiting means for limiting a frequency band of the digital audio signal to produce a series of band limited audio data of a band limited digital audio signal from the digital audio signal;

data removing means for removing pieces of band limited  
25 audio data from the series of band limited audio data produced

by the frequency band limiting means at prescribed intervals to produce a series of sampling frequency reduced data  $\{X_{ci}\}$  ( $i$  is a positive integral number) of a sampling frequency reduced signal from the band limited digital audio signal;

5 data thinning-out means for thinning out data of the digital audio signal to produce a series of thinned-out audio data  $\{X_{bi}, X_{ai}\}$  of a thinned-out audio signal in which the number of thinned-out audio data is double the number of sampling frequency reduced data of the sampling frequency reduced signal;

10 first differential audio data producing means for calculating a difference  $\Delta 1i = X_{bi} - X_{ci}$  between each piece of thinned-out audio data  $X_{bi}$  produced by the data thinning-out means and a corresponding piece of sampling frequency reduced data  $X_{ci}$  produced by the data removing means to produce a series of first differential audio data  $\{\Delta 1i\}$ ;

15 second differential audio data producing means for calculating a difference  $\Delta 2i = X_{ai} - X_{ci}$  between each piece of thinned-out audio data  $X_{ai}$  produced by the data thinning-out means and a corresponding piece of sampling frequency reduced data  $X_{ci}$  produced by the data removing means to produce a series of second differential audio data  $\{\Delta 2i\}$ ;

20 data packing means for packing the series of sampling frequency reduced data  $\{X_{ci}\}$  produced by the data removing means, the series of first differential audio data  $\{\Delta 1i\}$

produced by the first differential audio data producing means and the series of second differential audio data  $\{\Delta 2i\}$  produced by the second differential audio data producing means to produce a series of user data  $\{Xci, \Delta 1i, \Delta 2i\}$ ; and

5 coding means for packing the series of user data produced by the data packing means and the pieces of sound quality control information to produce the packed data.

9. An audio signal processing apparatus according to claim 7  
10 in which each piece of sound quality control information indicates the adjustment of the music in dependence on a category of the music such as classic, jazz, rock or background music, a playing condition of the music, a recording condition for the digital audio signal or  
15 circumstances of a reproducing condition of the digital audio signal.

10. An audio signal processing apparatus according to claim 7  
in which the analog audio signal is converted into the digital  
20 audio signal in the analog-digital converting means for each of a plurality of channels, and  
each piece of sound quality control information includes graphic equalizer information indicating the change of the original levels of the pieces of audio data of the digital  
25 audio signal for each frequency band, level balance

information indicating the change of the original levels of the pieces of audio data of the digital audio signal for each channel or reverberation adding information indicating the addition of reverberation to the music.

5

11. An audio signal recording medium, comprising:

10 a first data area for recording an digital audio signal composed of a plurality of pieces of audio data which are obtained by sampling an analog audio signal of a channel at a high sampling frequency; and

15 a second data area for recording a plurality of pieces of sound quality control information, which each denote information for adjusting a sound quality of a music indicated by the digital audio signal recorded in the first data area.

20

12. An audio signal recording medium according to claim 11 in which each piece of sound quality control information indicates the adjustment of the music in dependence on a category of the music such as classic, jazz, rock or background music, a playing condition of the music, a recording condition for the digital audio signal or circumstances of a reproducing condition of the digital audio signal.

25 13. An audio signal recording medium according to claim 11 in



which the digital audio signal is recorded in the first data area for each of a plurality of channels, and each piece of sound quality control information includes graphic equalizer information indicating the change of the original levels of the pieces of audio data of the digital audio signal for each frequency band, level balance information indicating the change of the original levels of the pieces of audio data of the digital audio signal for each channel or reverberation adding information indicating the addition of reverberation to the music.

14. An audio signal reproducing apparatus for reproducing an analog audio signal from packed data composed of a series of audio data, which is obtained by converting the analog audio signal of a channel, and a plurality of pieces of sound quality control information, which each denote information for adjusting a sound quality of a music indicated by the analog audio signal, comprising:

audio signal decoding means for decoding the packed data to reproduce the series of audio data and the pieces of sound quality control information;

operating means for receiving a user's instruction requesting the selection of a piece of particular sound quality control information from the pieces of sound quality control information reproduced by the audio signal decoding

means;

selecting means for selecting the piece of particular sound quality control information according to the user's instruction received by the operating means;

5     signal processing means for adjusting levels of the pieces of audio data reproduced by the audio signal decoding means according to the piece of particular sound quality control information selected by the selecting means to produce a series of sound quality adjusted audio data; and

10    audio data outputting means for outputting the series of sound quality adjusted audio data produced by the signal processing means.

15. An audio signal reproducing apparatus according to claim  
15 14, further comprising:

digital-analog converting means for converting the series of sound quality adjusted audio data produced by the signal processing means into a sound quality adjusted analog audio signal; and

20    analog audio signal outputting means for outputting the sound quality adjusted analog audio signal obtained by the digital-analog converting means to reproduce a sound quality adjusted music.

25 16. An audio signal reproducing apparatus according to claim

14 in which each piece of sound quality control information indicates the adjustment of the music in dependence on a category of the music such as classic, jazz, rock or background music, a playing condition of the music, a  
5 recording condition for the digital audio signal or circumstances of a reproducing condition of the digital audio signal.

17. An audio signal reproducing apparatus according to claim  
10 14 in which the packed data is decoded by the audio signal decoding means for each of a plurality of channels, and each piece of sound quality control information includes graphic equalizer information indicating the change of the original levels of the pieces of audio data of the digital audio signal  
15 for each frequency band, level balance information indicating the change of the original levels of the pieces of audio data of the digital audio signal for each channel or reverberation adding information indicating the addition of reverberation to a music indicated by the digital audio signal.

20

18. An audio signal processing and reproducing method, comprising the steps of:

converting an analog audio signal of a channel into a digital audio signal composed of a plurality of pieces of  
25 audio data;

shifting original levels of the pieces of audio data of the digital audio signal by a particular differential level to produce a level-shifted digital audio signal composed of a plurality of pieces of level-shifted audio data having shifted  
5 levels;

producing level shift control data indicating the particular differential level;

transmitting or recording the level-shifted digital audio signal and the level shift control data;

10 returning the shifted levels of the pieces of level-shifted audio data of the level-shifted digital audio signal transmitted or recorded to the original levels according to the level shift control data transmitted or recorded with the level-shifted digital audio signal to reproduce the pieces of  
15 audio data of the digital audio signal having the original levels; and

outputting the digital audio signal.

19. An audio signal processing and reproducing method  
20 according to claim 18, further comprising the steps of:

converting the digital audio signal reproduced from the level-shifted digital audio signal into the analog audio signal; and

outputting the analog audio signal converted from the  
25 digital audio signal.

20. An audio signal processing and reproducing method according to claim 18 in which the step of shifting original levels of the pieces of audio data comprises the steps of:

detecting a piece of particular audio data having a maximum  
5 original level from among the pieces of audio data;

calculating a difference between the maximum original level and an upper limit level allowed for the channel as the particular differential level; and

producing the pieces of level-shifted audio data of the  
10 level-shifted digital audio signal from the digital audio signal to set a particular shifted level of a piece of particular level-shifted audio data produced from the piece of particular audio data to the upper limit level.

21. An audio signal processing and reproducing method according to claim 18 in which the step of shifting original levels of the pieces of audio data comprises the steps of:

producing the level-shifted digital audio signal from the digital audio signal;

20 limiting a frequency band of the level-shifted digital audio signal to produce a series of band limited audio data of a band limited digital audio signal from the level-shifted digital audio signal;

removing pieces of band limited audio data from the series  
25 of band limited audio data at prescribed intervals to produce

a series of sampling frequency reduced data  $\{X_{ci}\}$  ( $i$  is a positive integral number) of a sampling frequency reduced signal from the series of band limited audio data;

thinning out pieces of data of the level-shifted digital  
5 audio signal at prescribed intervals to produce a series of thinned-out audio data  $\{X_{bi}, X_{ai}\}$  of a thinned-out audio signal in which the number of thinned-out audio data is double the number of sampling frequency reduced data;

calculating a difference  $\Delta 1_i = X_{bi} - X_{ci}$  between the thinned-  
10 out audio data  $X_{bi}$  and the sampling frequency reduced data  $X_{ci}$  to produce a series of first differential audio data  $\{\Delta 1_i\}$ ;

calculating a difference  $\Delta 2_i = X_{ai} - X_{ci}$  between the thinned-  
out audio data  $X_{ai}$  and the sampling frequency reduced data  $X_{ci}$  to produce a series of second differential audio data  $\{\Delta 2_i\}$ ;  
15 and

packing the series of sampling frequency reduced data  $\{X_{ci}\}$ , the series of first differential audio data  $\{\Delta 1_i\}$  and the series of second differential audio data  $\{\Delta 2_i\}$  to produce a series of user data  $\{X_{ci}, \Delta 1_i, \Delta 2_i\}$ ,  
20 the step of transmitting or recording the level-shifted digital audio signal comprising the steps of:

packing the series of user data and the level shift control data to produce packed data; and

recording the packed data in a digital versatile disk.

22. An audio signal processing and reproducing method according to claim 18 in which the step of transmitting or recording the level-shifted digital audio signal comprises the steps of:

5 preparing a plurality of pieces of audio reproduction control information respectively indicating information for adjusting a sound quality of a music indicated by the digital audio signal in dependence on a category of the music such as classic, jazz, rock or background music, a playing condition  
10 of the music, a recording condition for the level-shifted digital audio signal or circumstances of a reproducing condition of the digital audio signal; and

recording the level-shifted digital audio signal, the level shift control data and the pieces of audio reproduction  
15 control information in a digital versatile disk, and the step of returning the shifted levels of the pieces of level-shifted audio data comprises the steps of:

reading out the level-shifted digital audio signal, the level shift control data and the pieces of audio reproduction  
20 control information from the digital versatile disk;

reproducing the digital audio signal from the level-shifted digital audio signal according to the level shift control data;

selecting a piece of particular audio reproduction control  
25 information from among the pieces of audio reproduction

control information according to a category of a music  
indicated by the digital audio signal, a playing condition of  
the music, a recording condition for the level-shifted digital  
audio signal or circumstances of a reproducing condition of  
5 the digital audio signal; and

adjusting a sound quality of the music according to the  
particular audio reproduction control information.

23. An audio signal processing and reproducing method  
10 according to claim 22 in which the step of converting an  
analog audio signal of a channel into a digital audio signal  
includes a step of  
converting an analog audio signal into a digital audio signal  
for each of a plurality of channels, and  
15 each piece of sound quality control information includes  
graphic equalizer information indicating the change of the  
original levels of the pieces of audio data of the digital  
audio signal for each frequency band, level balance  
information indicating the change of the original levels of  
20 the pieces of audio data of the digital audio signal for each  
channel or reverberation adding information indicating the  
addition of reverberation to the music.

24. An audio signal processing and reproducing method  
25 according to claim 21 in which the step of returning the



shifted levels of the pieces of level-shifted audio data comprises the steps of:

reading out the packed data from the digital versatile disk;

5 reproducing the series of thinned-out audio data  $\{X_{bi}, X_{ai}\}$  from the packed data by adding each piece of sampling frequency reduced data  $X_{ci}$  to a corresponding piece of first differential audio data  $\Delta 1i$  and adding each piece of sampling frequency reduced data  $X_{ci}$  to a corresponding piece of second  
10 differential audio data  $\Delta 2i$ ;

interpolating pieces of data into the series of thinned-out audio data  $\{X_{bi}, X_{ai}\}$  to reproduce the pieces of level-shifted audio data of the level-shifted digital audio signal; and

returning the shifted levels of the pieces of level-shifted  
15 audio data of the level-shifted digital audio signal to the original levels according to the level shift control data to reproduce the digital audio signal.

25. An audio signal processing apparatus, comprising:

20 analog-digital converting means for converting an analog audio signal of a channel into a plurality of pieces of audio data of a digital audio signal;

level shifting means for shifting original levels of the pieces of audio data of the digital audio signal obtained by  
25 the analog-digital converting means by a particular

differential level to produce a plurality of pieces of level-shifted audio data of a level-shifted digital audio signal having shifted levels;

level shift control data producing means for producing  
5 level shift control data indicating the particular differential level; and

audio signal coding means for coding a set of the pieces of level-shifted audio data obtained by the level shifting means and the level shift control data produced by the level shift  
10 control data producing means to produce packed data, the packed data being transmitted or recorded.

26. An audio signal processing apparatus according to claim  
25 in which the audio signal coding means comprises:

15 frequency band limiting means for limiting a frequency band of the level-shifted digital audio signal to produce a series of band limited audio data of a band limited digital audio signal from the level-shifted digital audio signal;

data removing means for removing pieces of band limited  
20 audio data from the series of band limited audio data produced by the frequency band limiting means at prescribed intervals to produce a series of sampling frequency reduced data {Xci} (i is a positive integral number) of a sampling frequency reduced signal from the band limited digital audio signal;

25 data thinning-out means for thinning out data of the level-

shifted digital audio signal to produce a series of thinned-out audio data  $\{X_{bi}, X_{ai}\}$  of a thinned-out audio signal in which the number of thinned-out audio data is double the number of sampling frequency reduced data of the sampling  
5 frequency reduced signal;

first differential audio data producing means for calculating a difference  $\Delta 1_i = X_{bi} - X_{ci}$  between each piece of thinned-out audio data  $X_{bi}$  produced by the data thinning-out means and a corresponding piece of sampling frequency reduced  
10 data  $X_{ci}$  produced by the data removing means to produce a series of first differential audio data  $\{\Delta 1_i\}$ ;

second differential audio data producing means for calculating a difference  $\Delta 2_i = X_{ai} - X_{ci}$  between each piece of thinned-out audio data  $X_{ai}$  produced by the data thinning-out  
15 means and a corresponding piece of sampling frequency reduced data  $X_{ci}$  produced by the data removing means to produce a series of second differential audio data  $\{\Delta 2_i\}$ ;

data packing means for packing the series of sampling frequency reduced data  $\{X_{ci}\}$  produced by the data removing  
20 means, the series of first differential audio data  $\{\Delta 1_i\}$  produced by the first differential audio data producing means and the series of second differential audio data  $\{\Delta 2_i\}$  produced by the second differential audio data producing means to produce a series of user data  $\{X_{ci}, \Delta 1_i, \Delta 2_i\}$ ; and  
25 coding means for packing the series of user data produced

by the data packing means and the level shift control data produced by the level shift control data producing means to produce the packed data.

5 27. An audio signal processing apparatus according to claim  
25 in which a plurality of pieces of sound quality control  
information, which each denote information for adjusting a  
sound quality of a music indicated by the analog audio signal,  
are added to the digital audio signal by the audio signal  
10 coding means and the pieces of sound quality control  
information are coded with the digital audio signal by the  
audio signal coding means to produce packed data.

28. An audio signal processing apparatus according to claim  
15 27 in which each piece of sound quality control information  
indicates the adjustment of the music in dependence on a  
category of the music such as classic, jazz, rock or  
background music, a playing condition of the music, a  
recording condition for the digital audio signal or  
20 circumstances of a reproducing condition of the digital audio  
signal.

29. An audio signal processing apparatus according to claim  
27 in which the analog audio signal is converted into the  
25 digital audio signal in the analog-digital converting means

for each of a plurality of channels, and  
each piece of sound quality control information includes  
graphic equalizer information indicating the change of the  
original levels of the pieces of audio data of the digital  
5 audio signal for each frequency band, level balance  
information indicating the change of the original levels of  
the pieces of audio data of the digital audio signal for each  
channel or reverberation adding information indicating the  
addition of reverberation to the music.

10

30. An audio signal recording medium, comprising:

a first data area for recording a series of level-shifted  
audio data having shifted levels which is obtained by  
converting an analog audio signal of a channel into pieces of  
15 audio data and shifting original levels of the pieces of audio  
data by a particular differential level to the shifted levels;  
and

a second data area for recording level shift control data  
indicating the particular differential level used to obtain  
20 the series of level-shifted audio data recorded in the first  
data area.

31. An audio signal recording medium according to claim 30,  
further comprising:

25 a third data area for recording a plurality of pieces of

sound quality control information, which each denote information for adjusting a sound quality of a music indicated by the analog audio signal relating to the series of level-shifted audio data recorded in the first data area.

5

32. An audio signal recording medium according to claim 31 in which each piece of sound quality control information indicates the adjustment of the music in dependence on a category of the music such as classic, jazz, rock or background music, a playing condition of the music, a recording condition for the series of level-shifted audio data or circumstances of a reproducing condition of the series of level-shifted audio data.

33. An audio signal recording medium according to claim 31 in which the series of level-shifted audio data is recorded in the first data area for each of a plurality of channels, and each piece of sound quality control information includes graphic equalizer information indicating the change of the original levels of the level-shifted audio data for each frequency band, level balance information indicating the change of the original levels of the level-shifted audio data for each channel or reverberation adding information indicating the addition of reverberation to the music.

25

34. An audio signal reproducing apparatus for reproducing an analog audio signal from packed data composed of a series of level-shifted audio data having shifted levels, which is obtained by converting the analog audio signal of a channel  
5 into pieces of audio data and shifting original levels of the pieces of audio data by a particular differential level to the shifted levels, and level shift control data indicating the particular differential level, comprising:

audio signal decoding means for decoding the packed data to  
10 reproduce the series of level-shifted audio data and the level shift control data; and

signal processing means for returning the shifted levels of the pieces of level-shifted audio data obtained by the audio signal decoding means to the original levels to reproduce the  
15 pieces of audio data of the digital audio signal according to the level shift control data.

35. An audio signal reproducing apparatus according to claim 34, further comprising:

20 digital-analog converting means for converting the pieces of audio data reproduced by the signal processing means to the analog audio signal and outputting the analog audio signal.

36. An audio signal reproducing apparatus according to claim  
25 34, further comprising:

frequency band limiting means for limiting a frequency band of a digital audio signal composed of the pieces of audio data reproduced by the signal processing means to produce a band limited digital audio signal and outputting the band limited digital audio signal.

37. An audio signal reproducing apparatus according to claim 34, further comprising:

operating means for receiving a user's instruction requesting that the shifted levels of the pieces of level-shifted audio data be returned to the original levels; and control means for controlling the signal processing means to return the shifted levels of the pieces of level-shifted audio data to the original levels in cases where the user's instruction is received by the operating means.

38. An audio signal reproducing apparatus according to claim 34 in which the signal processing means comprises:

receiving means for receiving the packed data which is produced by limiting a frequency band of a level-shifted digital audio signal composed of the pieces of level-shifted audio data to produce a series of band limited audio data of a band limited audio signal from the level-shifted digital audio signal, removing pieces of band limited audio data from the band limited audio signal at prescribed intervals to produce a



series of sampling frequency reduced data  $\{X_{ci}\}$  ( $i$  is a positive integral number) of a sampling frequency reduced signal from the band limited audio signal, thinning out pieces of data of the level-shifted digital audio signal to produce a series of thinned-out audio data  $\{X_{bi}, X_{ai}\}$  of a thinned-out audio signal in which the number of thinned-out audio data is double the number of sampling frequency reduced data, calculating a difference  $\Delta 1i = X_{bi} - X_{ci}$  between each piece of thinned-out audio data  $X_{bi}$  and a corresponding piece of sampling frequency reduced data  $X_{ci}$  to produce a series of first differential audio data  $\{\Delta 1i\}$ , calculating a difference  $\Delta 2i = X_{ai} - X_{ci}$  between each piece of thinned-out audio data  $X_{ai}$  and a corresponding piece of sampling frequency reduced data  $X_{ci}$  to produce a series of second differential audio data  $\{\Delta 2i\}$ , packing the series of sampling frequency reduced data  $\{X_{ci}\}$ , the series of first differential audio data  $\{\Delta 1i\}$  and the series of second differential audio data  $\{\Delta 2i\}$  to produce a series of user data  $\{X_{ci}, \Delta 1i, \Delta 2i\}$  and packing the series of user data and the level shift control data to produce the packed data;

thinned-out audio data reproducing means for reproducing the series of thinned-out audio data  $\{X_{bi}, X_{ai}\}$  from the packed data received by the receiving means by adding each piece of sampling frequency reduced data  $X_{ci}$  to a corresponding piece of first differential audio data  $\Delta 1i$  included in the packed

data and adding each piece of sampling frequency reduced data Xci to a corresponding piece of second differential audio data  $\Delta 2i$  included in the packed data;

interpolation processing means for interpolating piece of  
5 data into the series of thinned-out audio data {Xbi, Xai}  
reproduced by the thinned-out audio data reproducing means to  
reproduce the level-shifted digital audio signal; and

level control means for returning the shifted levels of the  
pieces of level-shifted audio data of the level-shifted  
10 digital audio signal reproduced by the interpolation  
processing means to the original levels according to the level  
shift control data to reproduce the digital audio signal.

39. An audio signal reproducing apparatus according to claim  
15 34 in which the signal processing means comprises:

receiving means for receiving the packed data composed of  
the series of level-shifted audio data, the level shift  
control data and audio reproduction control information, the  
audio reproduction control information indicating information  
20 for adjusting a sound quality of a music indicated by the  
digital audio signal in dependence on a category of the music  
such as classic, jazz, rock or background music, a playing  
condition of the music, a recording condition for the level-  
shifted digital audio signal or circumstances of a reproducing  
25 condition of the digital audio signal; and

level and sound quality control means for returning the shifted levels of the pieces of level-shifted audio data to the original levels, adjusting a sound quality of the music by changing the original levels of the pieces of audio data of  
5 the digital audio signal according to the audio reproduction control information and outputting a series of sound quality adjusted audio data of a sound quality adjusted digital audio signal to reproduce a sound quality adjusted music.

10 40. An audio signal processing and reproducing method, comprising the steps of:

converting a series of analog audio signals, into which a test tone signal is inserted, into a series of digital audio signals including a test tone digital signal obtained by  
15 converting the test tone signal;

arranging each of the digital audio signals in an audio pack;

arranging the test tone digital signal in a test tone audio pack to produce a series of audio packs including the test  
20 tone audio pack;

dividing the series of audio packs including the test tone audio pack into a plurality of groups of audio packs;

allocating an audio control pack, in which control information is arranged, to each group of audio packs to set  
25 the control information and one group of digital audio signals

arranged in one group of audio packs as packed data;

adding mute control information indicating the performance of a mute control to the control information of one piece of packed data in cases where the test tone digital signal is

5 included in the piece of packed data;

recording the pieces of packed data;

reading out the pieces of packed data;

decoding the pieces of packed data to reproduce the control information and one group of digital audio signals from each  
10 piece of packed data, the mute control information being reproduced from one piece of packed data in which the test tone digital signal is included;

adjusting levels of the digital audio signals reproduced from the pieces of packed data according to the test tone  
15 digital signal;

outputting a sound indicated by one group of digital audio signals reproduced from one piece of packed data for each piece of packed data in cases where any mute control information is not included in the control information of the  
20 packed data; and

muting a sound of one group of digital audio signals reproduced from one piece of packed data according to the mute control in cases where the mute control information is included in the control information of the packed data.

25

41. An audio signal processing and reproducing method according to claim 40 in which the step of converting a plurality of analog audio signals includes the steps of:

5 preparing a plurality of sine waves as the test tone signal; and

setting a level of the test tone signal to a value higher than any of levels of the analog audio signals.

42. An audio signal processing and reproducing method according to claim 40 in which the step of adding mute control information includes a step of:

10 preparing a mute flag expressed by one byte as the mute control information.

43. An audio signal processing and reproducing method according to claim 40, further comprises the steps of:

15 receiving a mute instruction manually input by a user; and  
muting a sound of digital audio signals reproduced from pieces of packed data according to the mute instruction  
20 regardless of whether the mute control information is included in the control information.

44. An audio signal processing and reproducing method according to claim 40 in which the step of adding mute control  
25 information comprises the steps of:

preparing a plurality of pieces of audio reproduction control information respectively indicating information for adjusting a sound quality of a music indicated by the digital audio signals of pieces of packed data in dependence on a category of the music such as classic, jazz, rock or background music, a playing condition of the music, a recording condition for the digital audio signals or circumstances of a reproducing condition of the digital audio signals, and

the step of adjusting levels of the digital audio signals includes the steps of:

selecting a piece of particular audio reproduction control information from among the pieces of audio reproduction control information according to a category of the music, a playing condition of the music, a recording condition for the digital audio signals or circumstances of a reproducing condition of the digital audio signals; and

adjusting a sound quality of the music according to the particular audio reproduction control information.

45. An audio signal processing and reproducing method according to claim 44 in which the step of converting a plurality of analog audio signals includes a step of converting a plurality of analog audio signals, into which a test tone signal is inserted, into a plurality of digital

audio signal for each of a plurality of channels, and each piece of sound quality control information includes graphic equalizer information indicating the change of the original levels of the pieces of audio data of the digital audio signal for each frequency band, level balance information indicating the change of the original levels of the pieces of audio data of the digital audio signal for each channel or reverberation adding information indicating the addition of reverberation to the music.

46. An audio signal processing and reproducing method according to claim 40 in which the step of arranging each of the digital audio signals comprises the steps of:

limiting a frequency band of one digital audio signal to produce a series of band limited audio data of a band limited digital audio signal from the digital audio signal for each digital audio signal;

removing pieces of band limited audio data from the series of band limited audio data at prescribed intervals to produce a series of sampling frequency reduced data  $\{X_{ci}\}$  ( $i$  is a positive integral number) of a sampling frequency reduced signal from the series of band limited audio data;

thinning out pieces of data of the digital audio signal at prescribed intervals to produce a series of thinned-out audio data  $\{X_{bi}, X_{ai}\}$  of a thinned-out audio signal in which the

number of thinned-out audio data is double the number of sampling frequency reduced data;

calculating a difference  $\Delta 1i = X_{bi} - X_{ci}$  between the thinned-out audio data  $X_{bi}$  and the sampling frequency reduced data  $X_{ci}$  to produce a series of first differential audio data  $\{\Delta 1i\}$ ;

calculating a difference  $\Delta 2i = X_{ai} - X_{ci}$  between the thinned-out audio data  $X_{ai}$  and the sampling frequency reduced data  $X_{ci}$  to produce a series of second differential audio data  $\{\Delta 2i\}$ ; and

arranging the series of sampling frequency reduced data  $\{X_{ci}\}$ , the series of first differential audio data  $\{\Delta 1i\}$  and the series of second differential audio data  $\{\Delta 2i\}$  in one audio pack as a series of user data  $\{X_{ci}, \Delta 1i, \Delta 2i\}$ .

47. An audio signal processing apparatus, comprising:

analog-digital converting means for converting a plurality of analog audio signals, into which a test tone signal is inserted, into a plurality of digital audio signals respectively composed of a plurality of pieces of audio data, the test tone signal being converted into a test tone digital signal;

audio signal processing means for arranging each of the digital audio signals produced by the analog-digital converting means in an audio pack and arranging the test tone digital signal in a test tone audio pack;



audio signal coding means for dividing the audio packs and the test tone audio pack into a plurality of groups of audio packs, allocating an audio control pack, in which control information is arranged, to each group of audio packs to set  
5 the control information and one group of digital audio signals as packed data for each group of digital audio signals, adding mute control information indicating the performance of a mute control to the control information of one audio control pack, in cases where the test tone audio pack is included in one  
10 group of audio packs, and transmitting pieces of packed data to mute a sound of one group of digital audio signals of one piece of packed data in cases where the mute control information is included in the control information of the series of packed data.

15

48. An audio signal processing apparatus according to claim 47 in which the audio signal coding means comprises:

frequency band limiting means for limiting a frequency band of one digital audio signal to produce a series of band  
20 limited audio data of a band limited digital audio signal from the digital audio signal for each digital audio signal;

data removing means for removing pieces of band limited audio data from the series of band limited audio data produced by the frequency band limiting means at prescribed intervals  
25 to produce a series of sampling frequency reduced data {Xci}

(i is a positive integral number) of a sampling frequency reduced signal from the band limited digital audio signal;

data thinning-out means for thinning out data of the digital audio signal to produce a series of thinned-out audio data {X<sub>bi</sub>, X<sub>ai</sub>} of a thinned-out audio signal in which the number of thinned-out audio data is double the number of sampling frequency reduced data of the sampling frequency reduced signal;

first differential audio data producing means for calculating a difference  $\Delta 1i = X_{bi} - X_{ci}$  between each piece of thinned-out audio data X<sub>bi</sub> produced by the data thinning-out means and a corresponding piece of sampling frequency reduced data X<sub>ci</sub> produced by the data removing means to produce a series of first differential audio data { $\Delta 1i$ };

second differential audio data producing means for calculating a difference  $\Delta 2i = X_{ai} - X_{ci}$  between each piece of thinned-out audio data X<sub>ai</sub> produced by the data thinning-out means and a corresponding piece of sampling frequency reduced data X<sub>ci</sub> produced by the data removing means to produce a series of second differential audio data { $\Delta 2i$ };

data arranging means for arranging the series of sampling frequency reduced data {X<sub>ci</sub>} produced by the data removing means, the series of first differential audio data { $\Delta 1i$ } produced by the first differential audio data producing means and the series of second differential audio data { $\Delta 2i$ }

produced by the second differential audio data producing means as a series of user data  $\{X_{ci}, \Delta 1i, \Delta 2i\}$ ; and

coding means for packing the series of user data produced by the data packing means and the control information to  
5 produce one piece of packed data.

49. An audio signal processing apparatus according to claim 47 in which a plurality of pieces of audio reproduction control information are added to the control information by the audio  
10 signal coding means for each audio control pack, each audio reproduction control information indicating information for adjusting a sound quality of a music indicated by the digital audio signals of pieces of packed data in dependence on a category of the music such as classic, jazz, rock or  
15 background music, a playing condition of the music, a recording condition for the digital audio signals or circumstances of a reproducing condition of the digital audio signals.

20 50. An audio signal processing apparatus according to claim 49 in which a plurality of analog audio signals, into which a test tone signal is inserted, are converted into a plurality of digital audio signals for each of a plurality of channels by the analog-digital converting means, and  
25 each piece of sound quality control information includes

graphic equalizer information indicating the change of the original levels of the pieces of audio data of the digital audio signal for each frequency band, level balance information indicating the change of the original levels of the pieces of audio data of the digital audio signal for each channel or reverberation adding information indicating the addition of reverberation to the music.

51. An audio signal recording medium, comprising:

10 a plurality of first data areas for respectively recording a series of first packed data obtained by converting a plurality of analog audio signals, into which a test tone signal is inserted, into a plurality of digital audio signals, arranging each of the digital audio signals in an audio pack, dividing the audio packs into a plurality of groups of audio packs, allocating a first audio control pack, in which control information indicating the control of the digital audio signals is arranged, to each group of audio packs to set the control information and one group of digital audio signals as one series of first packed data; and

a second data area for recording a series of second packed data obtained by converting a test tone signal inserted into the plurality of analog audio signals into a test tone digital signal, arranging the test tone digital signal in a test tone audio pack and allocating a second audio control pack, in

which control information indicating the control of the digital audio signals and mute control information indicating the performance of a mute control are arranged, to the test tone audio pack and one or more audio packs relating to one or more digital audio signals obtained from one or more analog audio signals adjacent to the test tone signal to set the control information, the mute control information and the digital audio signals as the series of second packed data, a sound of digital audio signals being muted according to the mute control in cases where the series of second packed data is reproduced.

52. An audio signal recording medium according to claim 51 in which a plurality of pieces of sound quality control information, which each denote information for adjusting a sound quality of a music indicated by the analog audio signals, are recorded with the control information and the mute control information in the second data area.

53. An audio signal recording medium according to claim 52 in which each piece of sound quality control information indicates the adjustment of the music in dependence on a category of the music such as classic, jazz, rock or background music, a playing condition of the music, a recording condition for the digital audio signals or

circumstances of a reproducing condition of the digital audio signals.

54. An audio signal recording medium according to claim 52 in  
5 which the digital audio signals are recorded in the first and  
second data areas for each of a plurality of channels, and  
each piece of sound quality control information includes  
graphic equalizer information indicating the change of the  
original levels of the digital audio signals for each  
10 frequency band, level balance information indicating the  
change of the original levels of the digital audio signals for  
each channel or reverberation adding information indicating  
the addition of reverberation to the music.

55. An audio signal reproducing apparatus for reproducing a  
series of analog audio signals, into which a test tone signal  
is inserted, from a series of packed data, which are obtained  
by converting the series of analog audio signals into a series  
of digital audio signals, converting the test tone signal into  
20 a test tone digital signal, arranging each of the digital  
audio signals in an audio pack, arranging the test tone  
digital signal in a test tone audio pack to produce a series  
of audio packs including the test tone audio pack, dividing  
the series of audio packs including the test tone audio pack  
25 into a plurality of groups of audio packs, allocating an audio

control pack, in which control information is arranged, to each group of audio packs to set the control information and one group of digital audio signals arranged in one group of audio packs as packed data, and adding mute control

5 information indicating the performance of a mute control to the control information of one piece of packed data in cases where the test tone digital signal is included in the piece of packed data, comprising:

audio signal decoding means for decoding the pieces of  
10 packed data to reproduce the control information and one group of digital audio signals for each piece of packed data, the mute control information being reproduced from one piece of packed data in which the test tone digital signal is included;

signal processing means for adjusting levels of the digital  
15 audio signals reproduced from the pieces of packed data by the audio signal decoding means according to the test tone digital signal;

control means for judging for each piece of control  
information whether or not the mute control information is  
20 included in the control information reproduced by the audio signal decoding means and outputting a mute control instruction to perform the mute control for a particular group of digital audio signals of a piece of particular packed data in cases where the mute control information is included in the  
25 control information of the piece of particular packed data;

and

mute control performing means for performing the mute control to mute an output sound of the particular group of digital audio signals according to the mute control

- 5 instruction output from the control means and outputting a sound of the groups of digital audio signals other than the particular group of digital audio signals.

56. An audio signal reproducing apparatus according to claim 10 55 in which the signal processing means comprises:

level indicating means for indicating the levels of the digital audio signals and a level of the test tone digital signal;

- 15 level adjustment receiving means for receiving a level adjusting instruction indicating a level change determined by a user who observes the level of the test tone digital signal indicated by the level indicating means; and

- 20 level adjustment performing means for adjusting the levels of the digital audio signals by the level change indicated by the level adjusting instruction received by the level adjustment receiving means.

57. An audio signal reproducing apparatus according to claim 55 in which the control means includes:

- 25 mute instruction receiving means for receiving a mute



instruction indicating a request of the mute control from a user, the mute control being performed for the groups of digital audio signals by the mute control performing means according to the mute instruction.

5

58. An audio signal reproducing apparatus according to claim 55 in which the signal processing means comprises:

receiving means for receiving the series of packed data which is produced by limiting a frequency band of one digital audio signal to produce a series of band limited audio data of a band limited digital audio signal from the digital audio signal for each digital audio signal, removing pieces of band limited audio data from the series of band limited audio data at prescribed intervals to produce a series of sampling frequency reduced data  $\{X_{ci}\}$  ( $i$  is a positive integral number) of a sampling frequency reduced signal from the series of band limited audio data, thinning out pieces of data of the digital audio signal at prescribed intervals to produce a series of thinned-out audio data  $\{X_{bi}, X_{ai}\}$  of a thinned-out audio signal in which the number of thinned-out audio data is double the number of sampling frequency reduced data, calculating a difference  $\Delta 1i = X_{bi} - X_{ci}$  between the thinned-out audio data  $X_{bi}$  and the sampling frequency reduced data  $X_{ci}$  to produce a series of first differential audio data  $\{\Delta 1i\}$ , calculating a difference  $\Delta 2i = X_{ai} - X_{ci}$  between the thinned-out audio data  $X_{ai}$

and the sampling frequency reduced data  $X_{ci}$  to produce a series of second differential audio data  $\{\Delta 2i\}$ , arranging the series of sampling frequency reduced data  $\{X_{ci}\}$ , the series of first differential audio data  $\{\Delta 1i\}$  and the series of second differential audio data  $\{\Delta 2i\}$  in one audio pack as a series of user data  $\{X_{ci}, \Delta 1i, \Delta 2i\}$  and packing the series of user data and the control information to produce one piece of packed data;

thinned-out audio data reproducing means for reproducing the series of thinned-out audio data  $\{X_{bi}, X_{ai}\}$  from the packed data received by the receiving means by adding each piece of sampling frequency reduced data  $X_{ci}$  to a corresponding piece of first differential audio data  $\Delta 1i$  included in the packed data and adding each piece of sampling frequency reduced data  $X_{ci}$  to a corresponding piece of second differential audio data  $\Delta 2i$  included in the packed data; and

interpolation processing means for interpolating piece of data into the series of thinned-out audio data  $\{X_{bi}, X_{ai}\}$  reproduced by the thinned-out audio data reproducing means to reproduce the digital audio signals.

59. An audio signal reproducing apparatus according to claim 55 in which the signal processing means comprises:

receiving means for receiving a plurality of pieces of audio reproduction control information respectively indicating

information for adjusting a sound quality of a music indicated  
by the digital audio signals of the series of packed data in  
dependence on a category of the music such as classic, jazz,  
rock or background music, a playing condition of the music, a  
5 recording condition for the digital audio signals or  
circumstances of a reproducing condition of the digital audio  
signals;

selecting means for selecting a piece of particular audio  
reproduction control information from among the pieces of  
10 audio reproduction control information according to a category  
of the music, a playing condition of the music, a recording  
condition for the digital audio signals or circumstances of a  
reproducing condition of the digital audio signals; and

sound quality adjusting means for adjusting a sound quality  
15 of the music according to the particular audio reproduction  
control information.